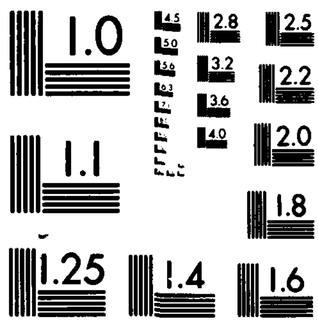
AD-A089 787 COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH F/G 8/8
SEDIMENT DISPLACEMENT IN THE OTTAUQUECHEE RIVER -- 1975-1978.(U)
MAY 80 C MARTINSON
UNCLASSIFIED CRREL-SR-80-20 NL

END
DATE
FILMED
11-80
DTIC



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

Special Report 80-28

May 1980

LEVEL

AD A089787

SEDIMENT DISPLACEMENT IN THE OTTAUQUECHEE RIVER—1975-1978

Carl Martinson

Prepared for
DIRECTORATE OF CIVIL WORKS
OFFICE OF THE CHIEF OF ENGINEERS
By

80 9 29 110

UNITED STATES ARMY
CORPS OF ENGINEERS
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE, U.S.A.

80 9 29 110

(14) CRREL-SR-80-20

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Special Report 80-20

2. GOVT ACCESSION NO.: AD-A089 787 (9)

3. RECIPIENT'S CATALOG NUMBER: Special rept.,

4. TITLE (and Subtitle): (6) SEDIMENT DISPLACEMENT IN THE OTTAUQUECHEE RIVER—1975-1978

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): (10) Carl Martinson

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS: U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire 03755

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: CWIS 31357

11. CONTROLLING OFFICE NAME AND ADDRESS: Directorate of Civil Works, Office of the Chief of Engineers, Washington, D.C. 20314

12. REPORT DATE: (11) May 1980

13. NUMBER OF PAGES: 17

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (12) 18

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Displacement
Hydrology
Ice
Rivers
Sediment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A three-year study of sediment displacement was conducted on a short section of the Ottauquechee River in Vermont that has erosional problems caused by ice. The results of cross-sectional surveys showed large quantities of the bank eroded and deposition in the bed within the study area. The erosion appears to have been caused by (1) the ice scouring the banks and (2) ice plugging the channel and diverting the flow toward the banks.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

037 100

JB

PREFACE

This report was prepared by Carl R. Martinson, Civil Engineering Technician, of the Ice Engineering Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory. Funding for this research was provided by U.S. Army Corps of Engineers Civil Works Project 31357, *Model Studies of Ice Jam Formation.*

The manuscript of this report was technically reviewed by Darryl Calkins and Steven Daly of CRREL. Doug Stewart and Joe Hryczkiewicz conducted the 1975 survey. In 1978 Heidi Deering and John Gagnon assisted in the field surveys for this study.

CONTENTS

ILLUSTRATIONS

TABLES

SEDIMENT DISPLACEMENT IN THE OTTAUQUECHEE RIVER—1975-1978

Carl Martinson

OBJECTIVES

This study covers a three-year period from 1975 to 1978. Its purpose was to determine the location and amount of channel erosion and deposition primarily caused by ice in a short section of the Ottauquechee River behind a small dam in Quechee, Vermont.

LOCATION OF STUDY

Using Horton's (1945) definition, the Ottauquechee River, in east-central Vermont, is a fifth-order river. It is a 41-mile-long tributary of the Connecticut River with a drainage area of 221 square miles and an average annual discharge of 396 ft^3/s. The maximum discharge for the period of record of 24,400 ft^3/s occurred in September 1938, and the minimum discharge of 2.9 ft^3/s occurred in July 1933. The study area (Fig. 1) lies 33.5 miles from the river's source.

Population along the river is sparse. The river travels through several rural communities, the largest of which is Woodstock, Vermont, with a population of approximately 1200. The drop in elevation from beginning to end is approximately 900 ft.

From the source to the study area, the river bottom is generally rocky, except for the backwaters of two small dams, one in Quechee and the other in Taftsville. In these areas, the river bottom is composed of silt.

The specific area used for this study is a reach extending from Downer's Mill Dam in Quechee, Vermont, to 3600 ft upstream. During average flow conditions the normal backwater from the dam extends approximately 2600 to 3000 ft upstream with a slope on the order of 10^{-4} and a natural slope of 10^{-3} in the unregulated portions (Deck 1978).

METHODS

The results of this study were obtained from two surveys. The first was an uncontrolled survey conducted in June 1975. Cross sections were established every 200 ft by measurement along the left bank.* Sixty-eight cross sections were initially surveyed and 18 of these were used for this study, with the rest being used for other studies. The first cross section immediately upstream of the dam begins with number 12.

Because additional work on the Ottauquechee River is planned, we conducted a second survey in August 1978. This survey was a closed traverse in which several of the original cross-section stations were incorporated as traverse stations. The remaining cross sections were then taped from the new traverse.

When the results from the two surveys were plotted and compared, it was apparent that the cross sections were not matched exactly. This was caused by a lack of control in the June 1975 survey. Three sections (13, 26 and 30) were deleted from the study. An example of nonalignment can be seen in Appendix A cross section 18 (Fig. A6). The others appear to match satisfactorily.

* In this report the right or left bank is referenced to an observer facing downstream.

Figure 1. Ottauquechee River showing locations of cross sections.

RIVER HISTORY

The United States Geological Survey has a water stage recorder below the U.S. Army Corps of Engineers flood control dam downstream of the study area in North Hartland, Vermont. Since the construction of the dam in 1961, the gauge data do not reflect the timing of natural hydrologic conditions in the watershed due to regulation practices at the dam. Ice jams and storm runoff in the Quechee, Vermont, area are not properly sequenced, and no correlation can be established.

The information in Figure 2 is taken from the United States Geological Survey Water Resources Data Reports (1974-1977). In 1976 there was an ice jam in January, and the ice went out in March. This event occurred after heavy rains caused a large increase in water level and consequently the breakup of the ice cover. The only major winter event of 1977 was an ice run in March. At the time of this writing, USGS water resources data were not available for 1978-1979. Major events that took place during this period included ice runs in January 1978, January 1979 and March 1979.

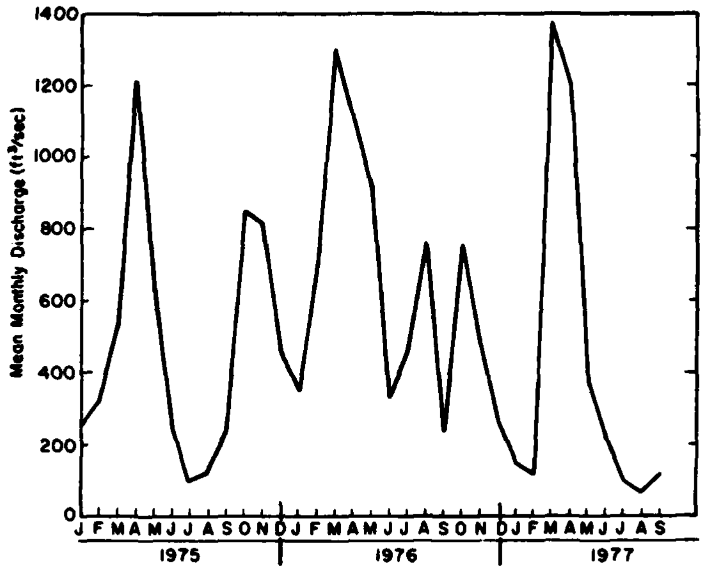


Figure 2. Mean monthly discharge from January 1975 to September 1977 (data from USGS 1974-1977).

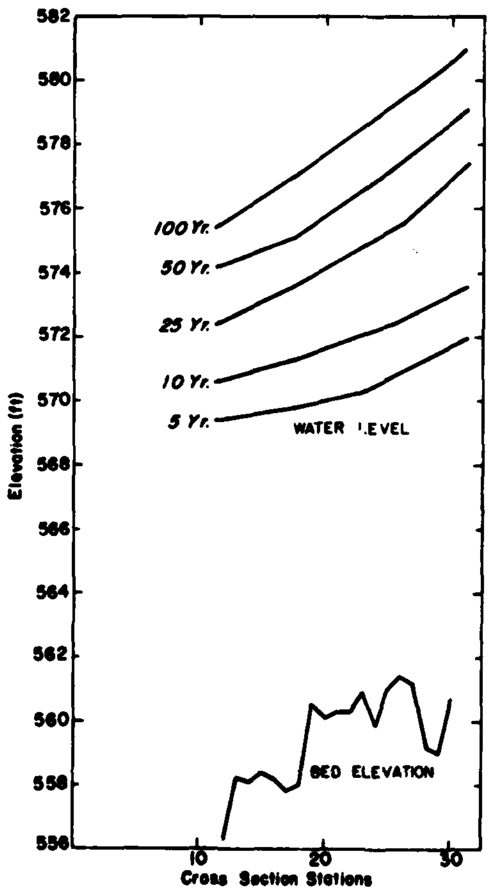


Figure 3. Computer-generated flow profile analysis of flood events on the Ottauquechee River. Water elevations for open water conditions from D'Appolonia Consulting Engineers Inc. Information supplied by Quechee Lakes Corporation, Quechee, Vermont.

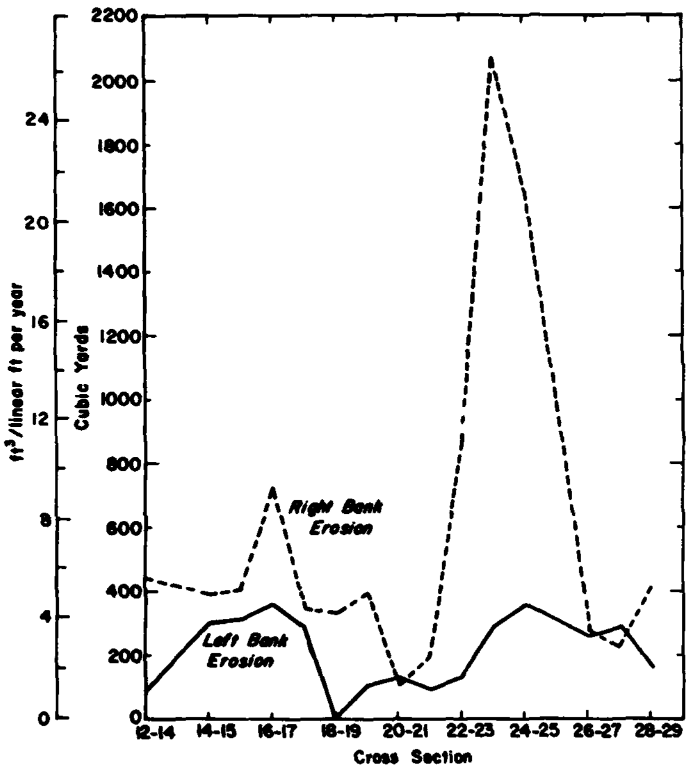


Figure 4. *Volumes of erosion occurring from 1975 to 1978.*

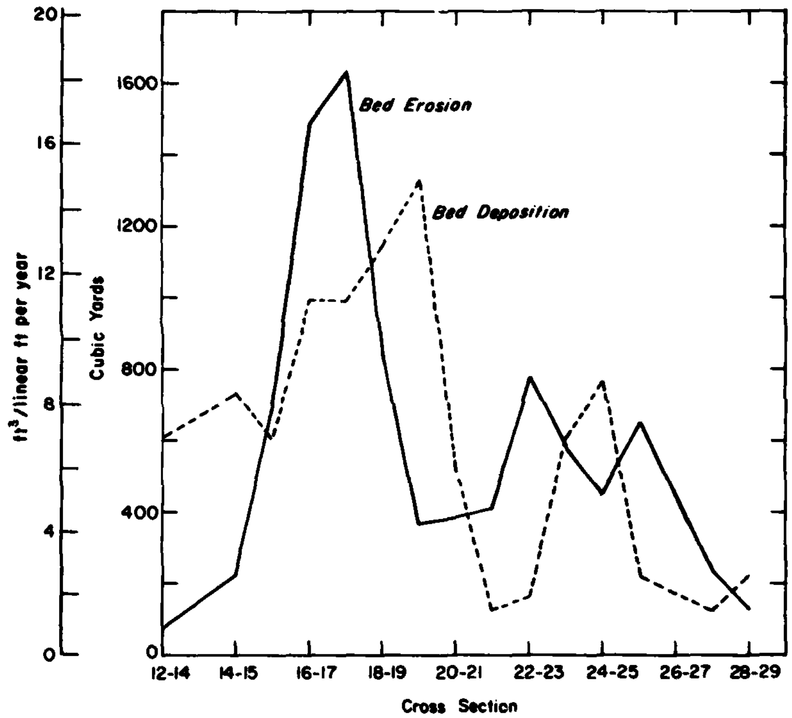


Figure 5. Volumes of deposition or erosion in the bed occurring from 1975 to 1978.

Figure 3 represents a computer-generated flow profile analysis of the 5-, 10-, 25-, 50- and 100-year flood events for open water conditions. During the last four years the flood levels for ice jam events have reached the 5-year level four times, the 10-year level three times, and the 50-year level once at one particular section of the river. A 5-year and 50-year flood event occurred on the same day but at different locations 2000 ft apart. This was due to the backwater effect of an ice jam in the river. The jam occurred in the area of cross sections 22 to 25, causing a 50-year flood level at cross section 30, but only a 5-year level at cross section 12.

Not coincidentally, cross sections 22 to 25 are also those where the greatest bank erosion of the river has occurred during the past three years. The widening can be attributed to the fact that this is an active ice jam formation site where jams normally form every year. This area is also the transition zone from the influence of the small dam to the unregulated portion of the river where ice jams usually occur.

Table 1. Volumes of erosion and deposition from 1975 to 1978.

Cross section	Vol. of bed eros. (yd^3)	Vol. of left bank eros. (yd^3)	Vol. of right bank eros. (yd^3)	Vol. of bed dep. (yd^3)
12-14	75.9	93.0	440.4	606.6
14-15	227.0	185.5	461.5	765.2
15-16	708.5	198.9	475.6	635.9
16-17	1486.3	361.5	731.1	989.3
17-18	1635.5	290.4	345.9	990.0
18-19	833.7	0	331.8	1141.1
19-20	366.6	105.9	398.9	1312.2
20-21	382.6	133.7	100.4	529.3
21-22	412.6	97.0	194.4	122.2
22-23	779.2	138.5	864.8	160.4
23-24	585.5	293.0	2075.5	612.2
24-25	449.6	359.6	1643.0	765.5
25-27	651.5	261.5	271.1	221.5
27-28	235.2	287.0	222.6	113.0
28-29	130.0	161.5	407.0	211.8
Totals	8959.7	2967.0	8964.0	9176.2
Ice jam (22-25)	1814.3	791.1	4583.3	1538.1
No ice jam	7145.4	2175.9	4380.7	7638.1

CONCLUSIONS

The results of calculations of a survey of the defined channel, which includes the banks and bed of the river, are included in the data in Table 1 and Figures 4 and 5.

Table 1 represents volumes of deposition and erosion in different parts of the study area. To obtain the values, the graphs in Appendix A were planimetered to obtain the difference of deposition or erosion of each cross section. To calculate the amount of erosion, these numbers were used as follows:

$$V = \frac{E_1 + E_2}{2} \times 200$$

where V = volume

E_1 = end area of deposition or erosion of a cross section

E_2 = end area of deposition or erosion of an adjacent cross section

200 = distance (ft) between cross sections.

When the data are analyzed, it can be seen that the greatest bank erosion occurs on the right bank from cross section 22 to 25. This is also where ice jams form. The main reasons for the large-scale erosion appear to be 1) ice scouring the banks during ice runs and 2) ice plugging the channel and diverting the flow toward the banks. The generally higher erosion along the right bank of the study area can be attributed to an approximately 50° curvature of the river to the left with a radius of 1400 ft at midchannel. This condition facilitates scouring of the right bank more than the left.

The largest amount of deposition in the bed occurs between cross sections 16 and 20. This deposition occurs on the left side of the channel at cross sections 16 to 19 and on the right side at cross section 20. The greatest bed erosion occurs from cross sections 16 to 18 on the right side of the channel where the river bends to the left. The flow velocity is lower on the inside of the bend, creating deposition in the bed, and higher on the outside, causing erosion of the bed and bank.

Erosion along the left bank removes an average of 7.4 ft^3 of soil per linear foot per year. Along the right bank, erosion averages 22.4 ft^3 per linear foot per year. Bed erosion and bed deposition are nearly equal at 22.4 ft^3 and 22.9 ft^3 per linear foot per year respectively. This similarity indicates that the bed volume has not changed but merely shifted.

In the area of cross sections 22 to 25 where the ice jams occur, the volume of the left bank erosion is 11.9 ft^3 per linear foot per year. In this area the erosion on the right bank averages 68.8 ft^3 per linear foot per year.

In the area where ice jams occur there is a significant increase in bank erosion from the average of the entire study area. Along the right bank the volume of erosion is 207% greater in the ice jam area than for the

the right bank's average volume of erosion. The left bank's volume of erosion in the ice jam area is 61% greater than the average volume of erosion of the left bank.

LITERATURE CITED

Deck, D. (1978) Growth rates and characteristics of ice on the Ottauquechee and Winooski Rivers of Vermont during winter 1977-78. CRREL Report 78-30.

Horton, R.E. (1945) Erosional development of streams and their drainage basins: Hydrophysical approach to qualitative morphology. *Bulletin, Geological Society of America*, vol. 56.

U.S. Geological Survey (1975-1977) Water resources data reports for New Hampshire and Vermont.

APPENDIX A: PLOTTED CROSS SECTIONS

All of the following cross sections are viewed with the observer facing downstream.

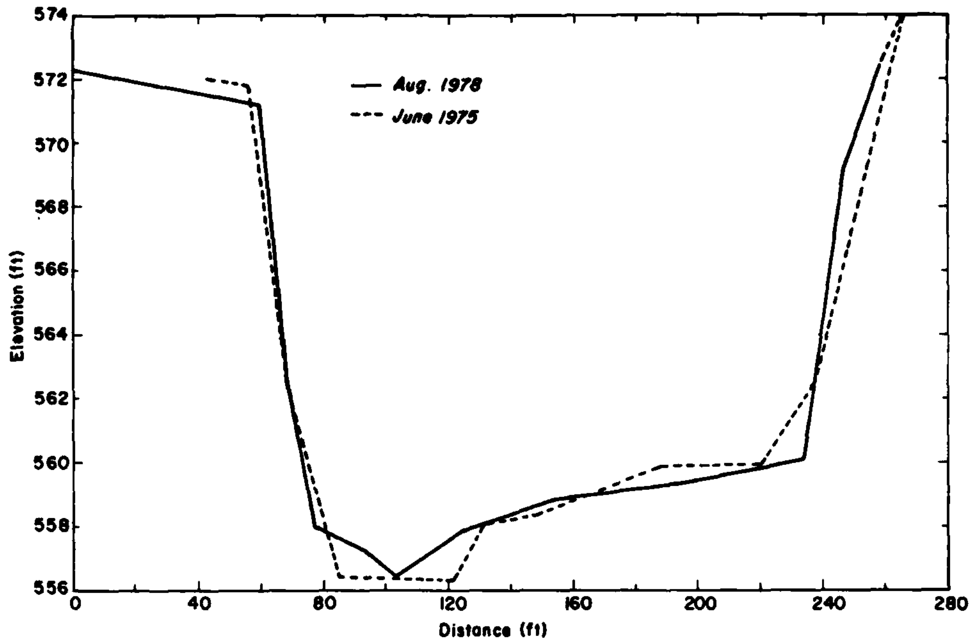


Figure A1. Cross section 12.

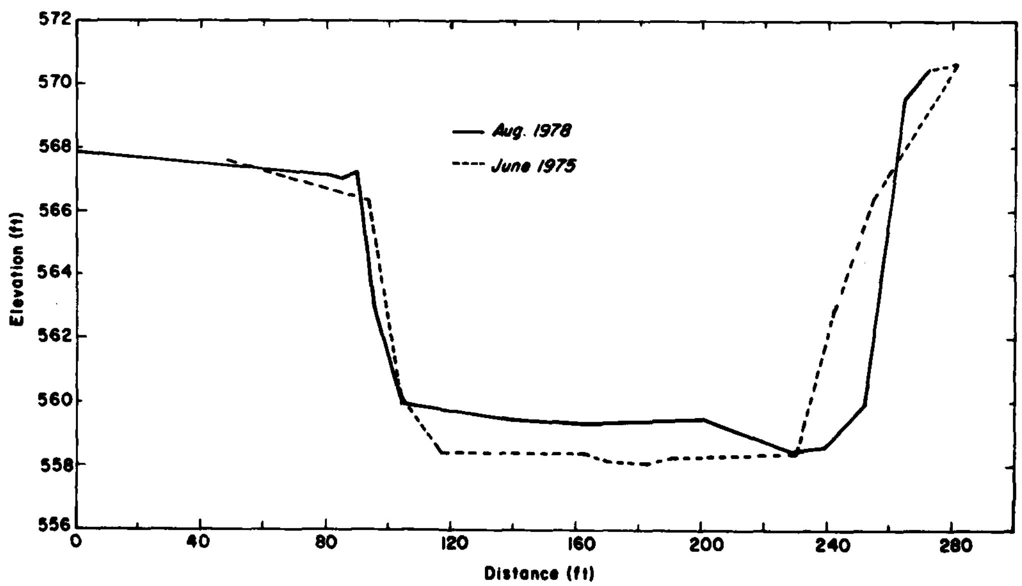


Figure A2. Cross section 14.

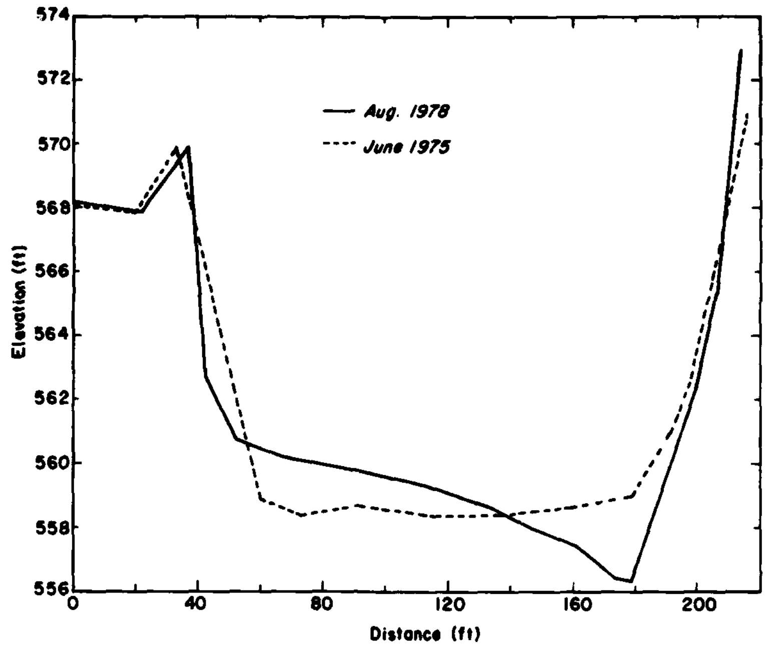


Figure A3. Cross section 15.

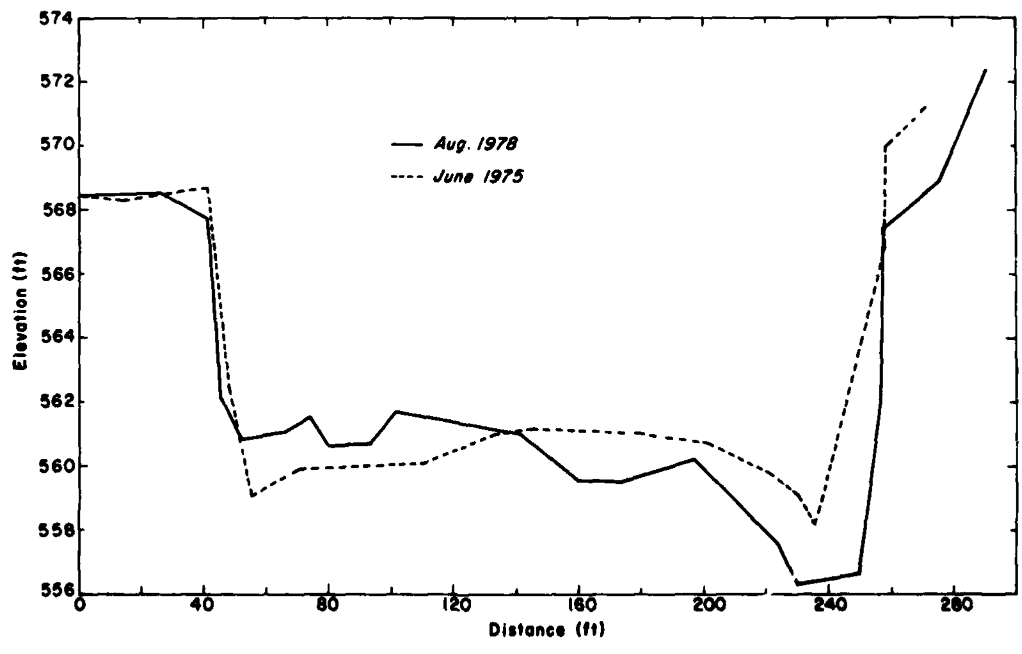


Figure A4. Cross section 16.

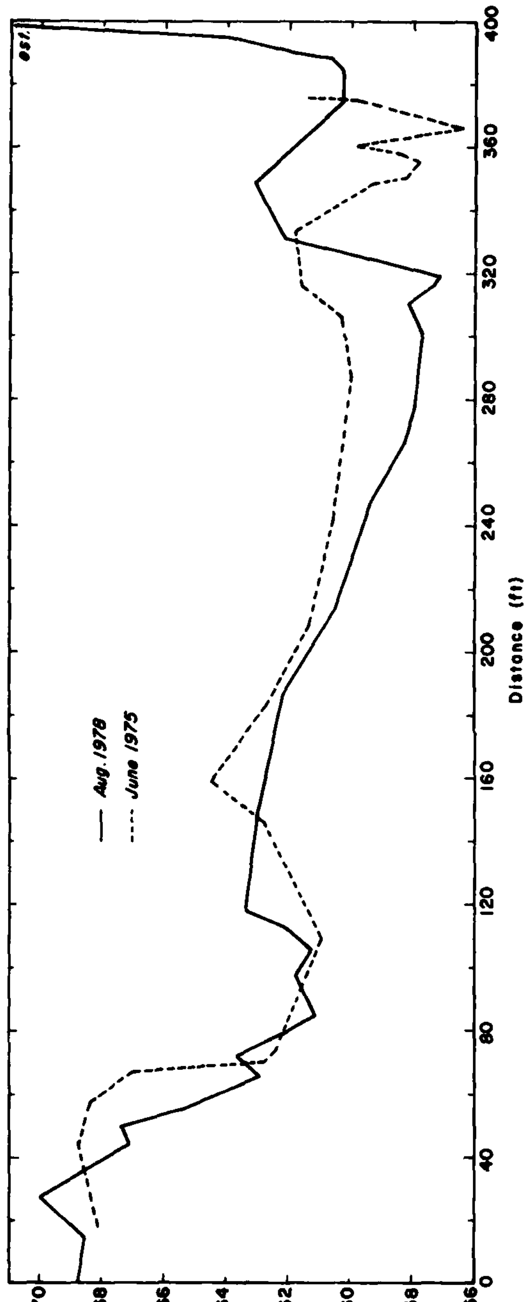


Figure A5. Cross section 17.

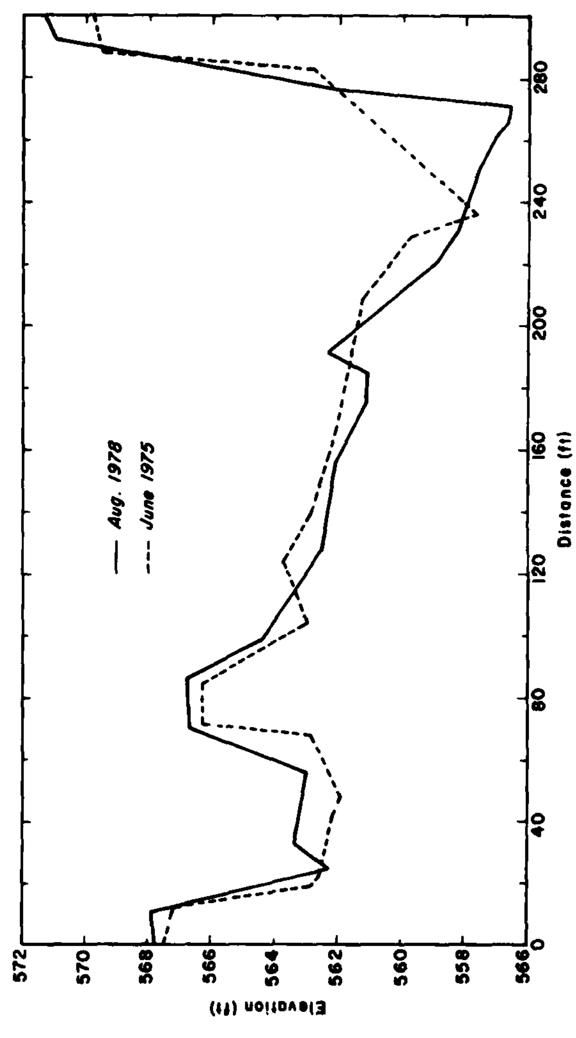


Figure A6. Cross section 18.

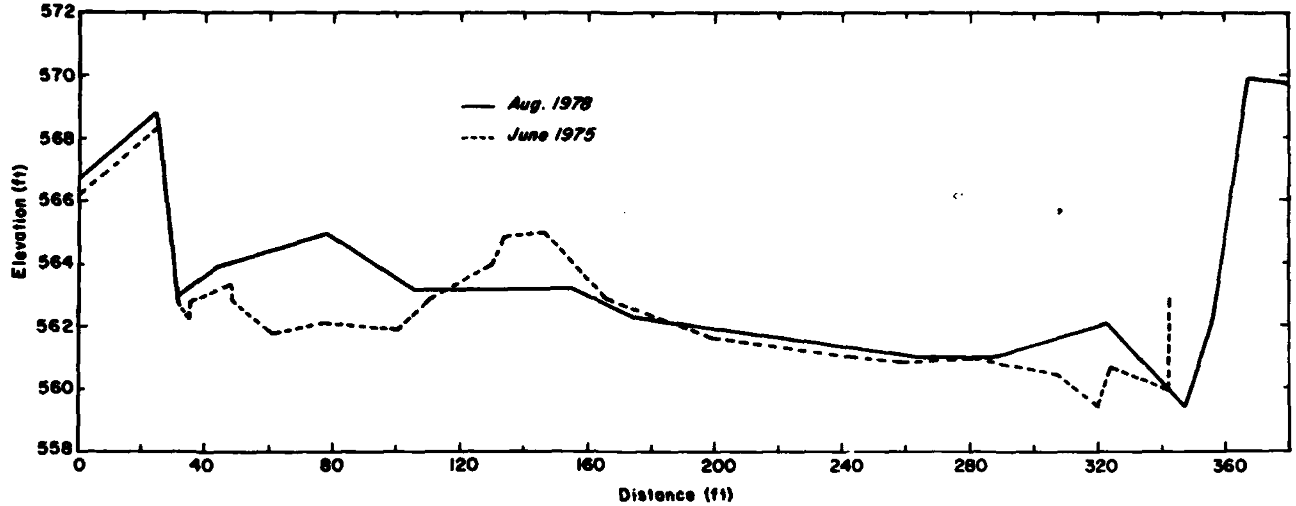


Figure A7. Cross section 19.

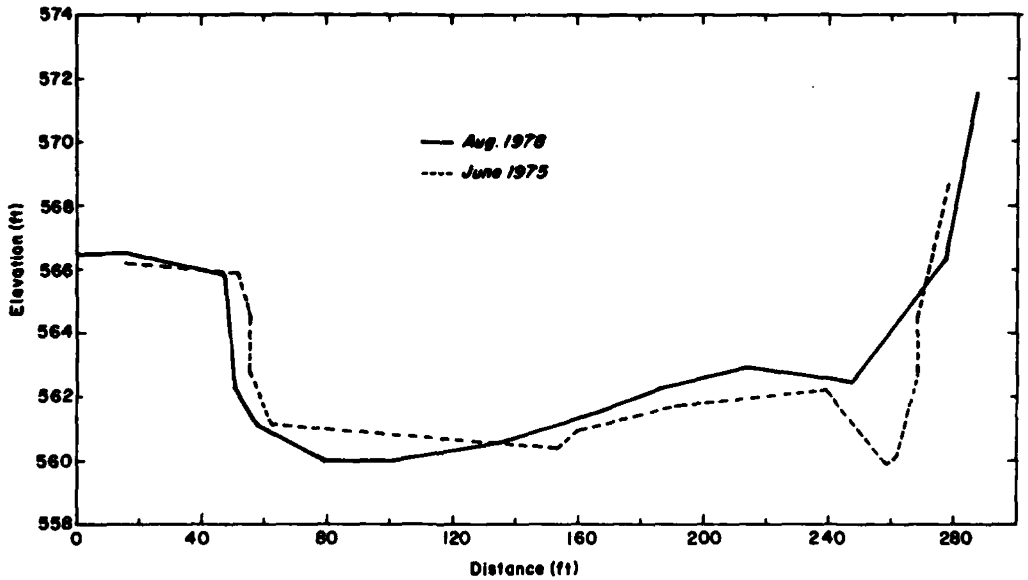


Figure A8. Cross section 20.

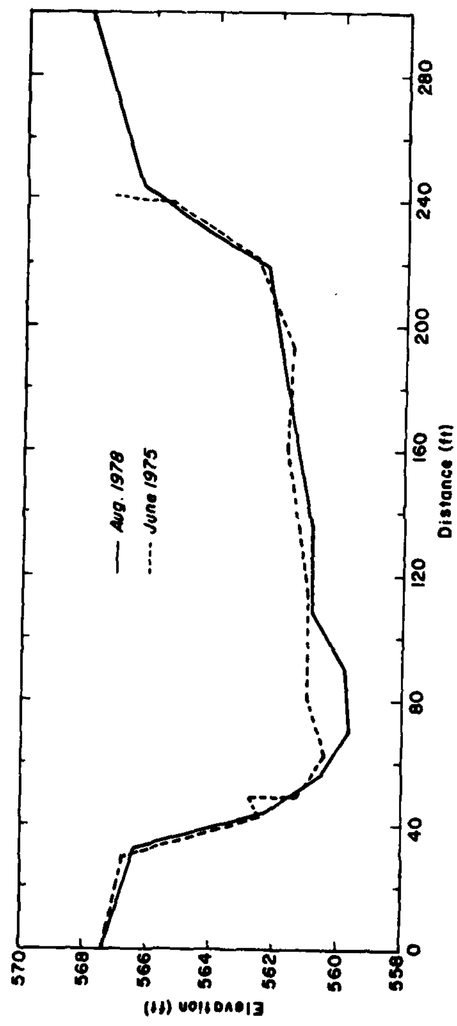


Figure A9. Cross section 21.

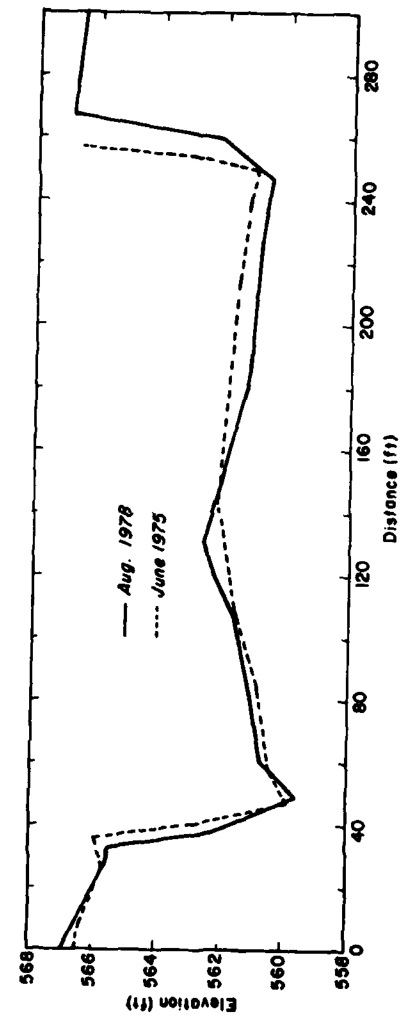


Figure A10. Cross section 22.

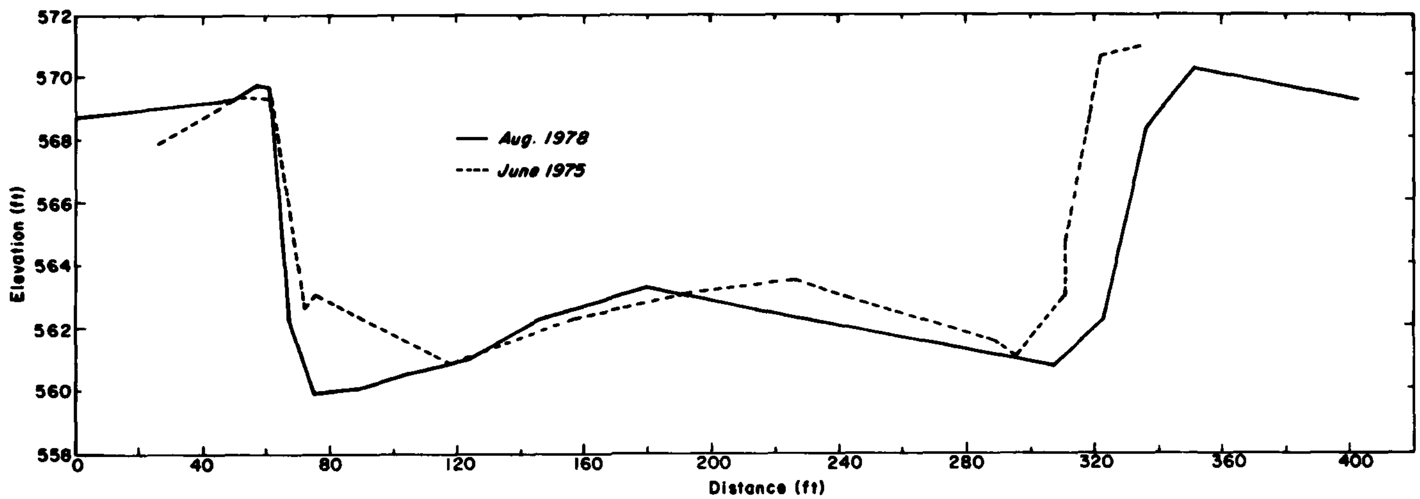


Figure A11. Cross section 23.

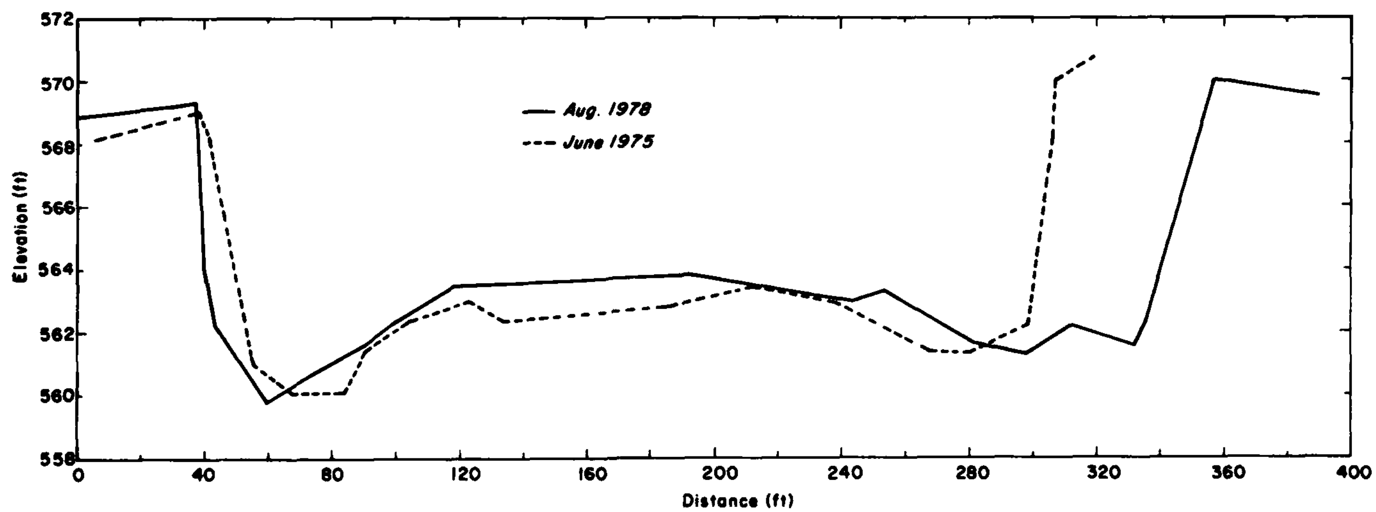


Figure A12. Cross section 24.

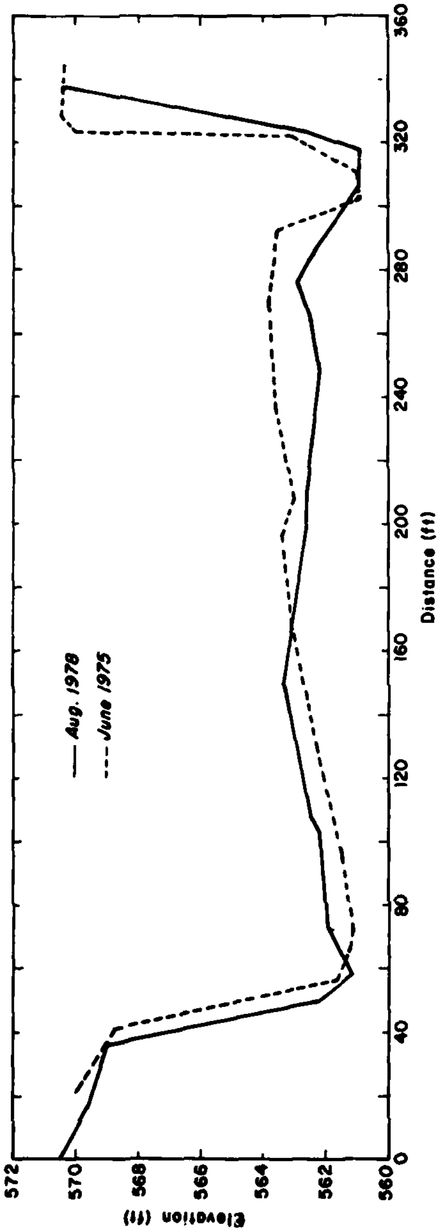


Figure A13. Cross section 25.

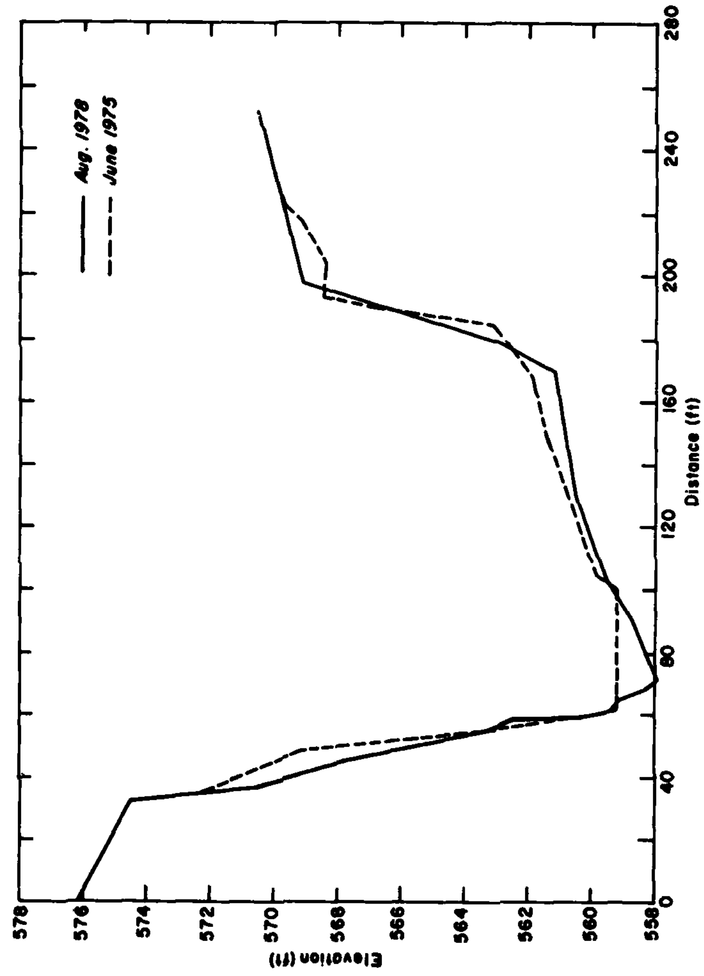


Figure A14. Cross section 27.

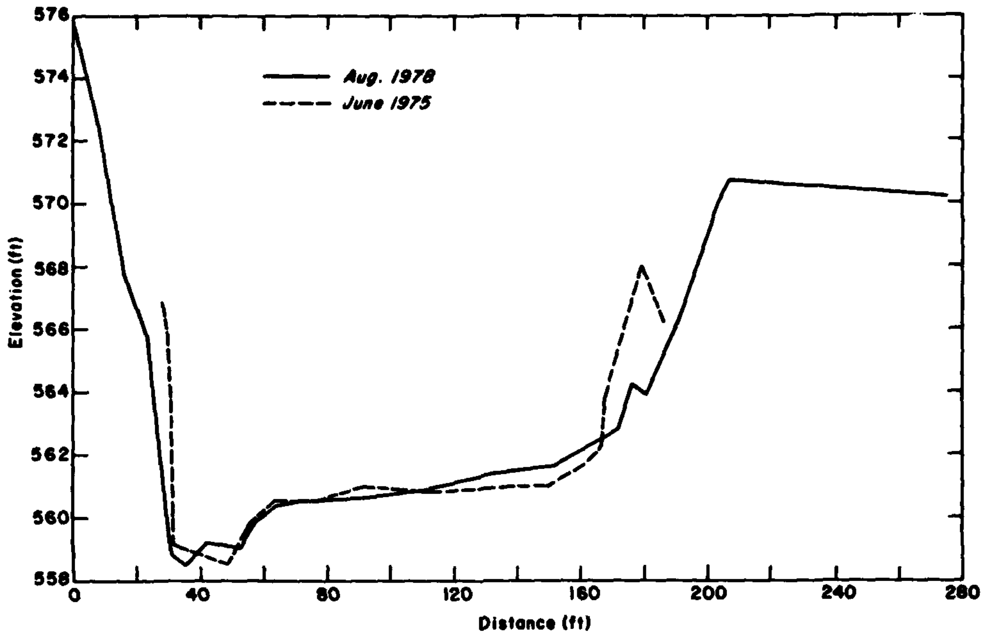


Figure A15. Cross section 28.

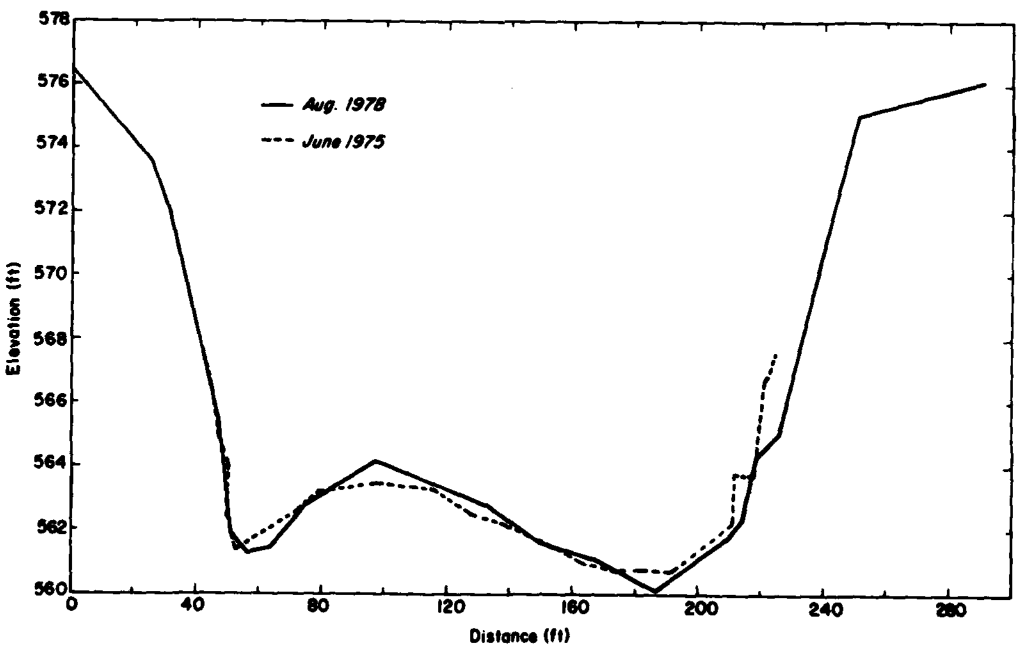


Figure A16. Cross section 29.

☆ U. S. GOVT. PRINTING OFFICE 1980 600-756 # 42